

Assessing the predictability of spring precursors to summer drought over Texas

*Nelun Fernando, Rong Fu, Bridget Scanlon,
Robert Mace, Ruben Solis,
Lei Yin and Adam Bowerman*

CFSv2 Evaluation Workshop (30/4/2012), Greenbelt, MD



Worst 1-year drought, hottest summer, record depletion in reservoir storage....



Source: TWPD



Source: TWPD



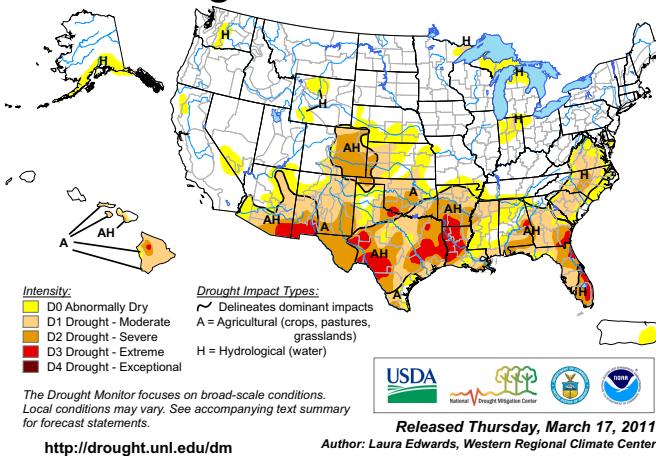
Source: TWPD

- \$US 7.62 Ag loss
- 3.7 million acres burned
- 40% decrease in reservoir storage

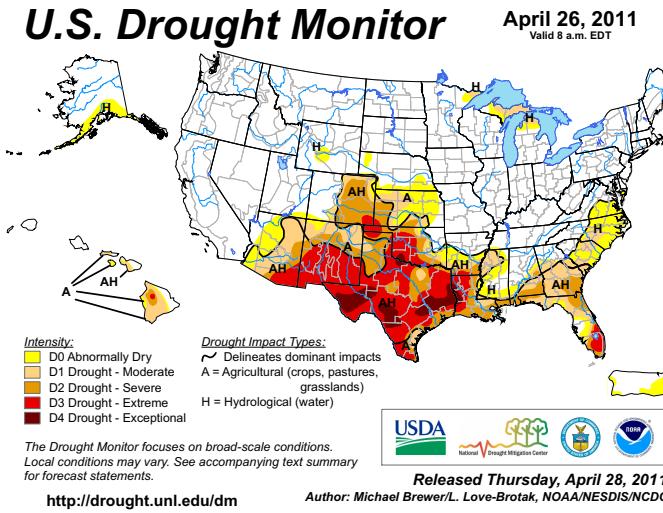


Rapid intensification in late-spring

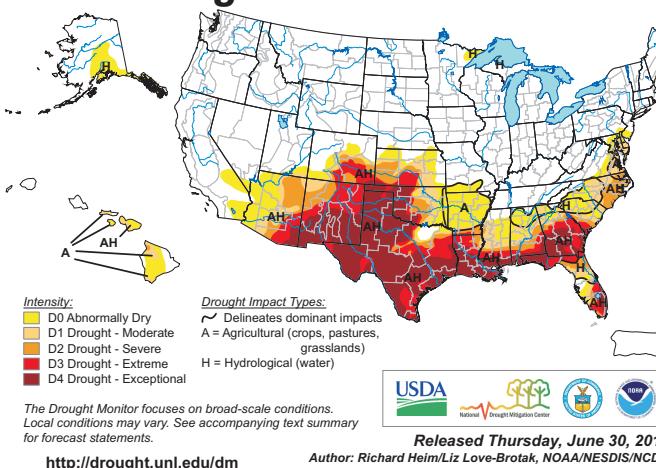
U.S. Drought Monitor



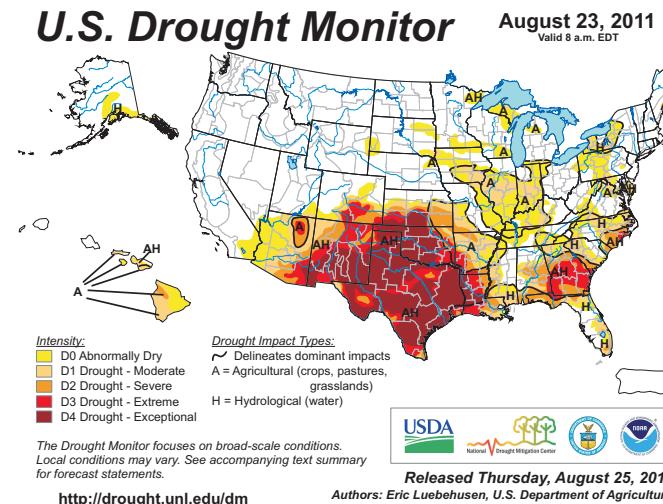
U.S. Drought Monitor



U.S. Drought Monitor



U.S. Drought Monitor

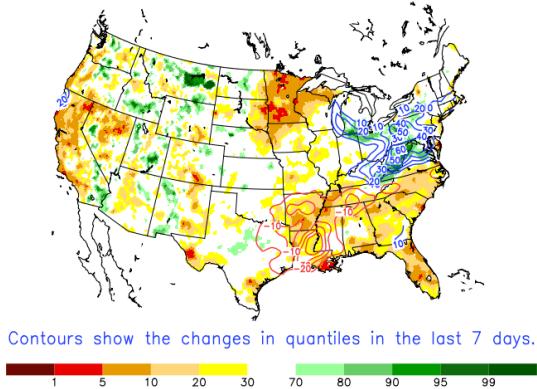


2011 forecast soil moisture

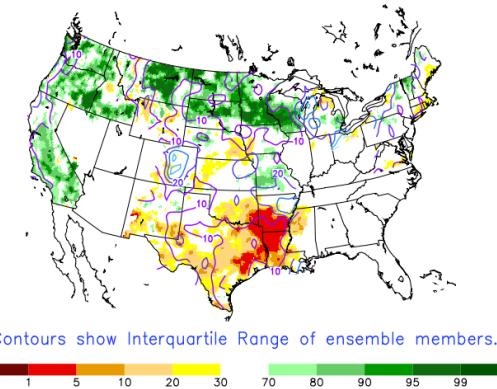
CFS most-likely and full ensemble predictions and EPS ensemble forecasts fail to predict the 2011 summer drought.

**CFS: Initial
soil moisture
anomaly (31
March 2011)**

Total Column Soil Moisture Percentiles on 20120301
(wrt samples within a 49-day window in 1951–2004)



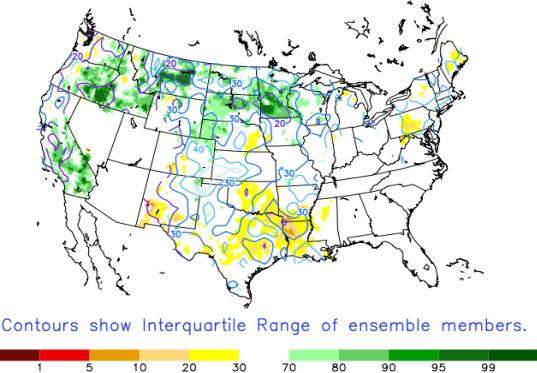
Experimental Drought Estimates based on CFS Forecast
Total Column Soil Moisture Percentiles (Median of Most Likely 7 Members)
APR2011 (init: 20110401)



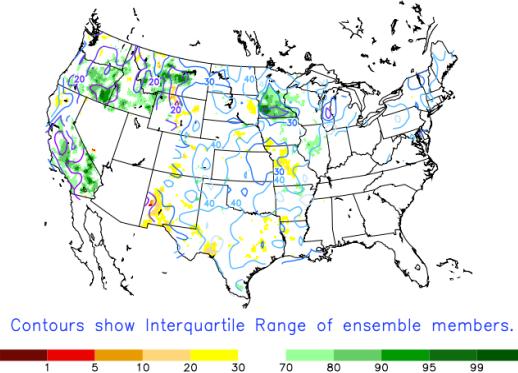
**CFS most-likely:
soil moisture
anomaly (April
2011)**

June 2011

Experimental Drought Estimates based on CFS Forecast
Total Column Soil Moisture Percentiles (Median of Full Ensemble)
JUN2011 (init: 20110401)



Experimental Drought Estimates based on CFS Forecast
Total Column Soil Moisture Percentiles (Median of Full Ensemble)
AUG2011 (init: 20110401)



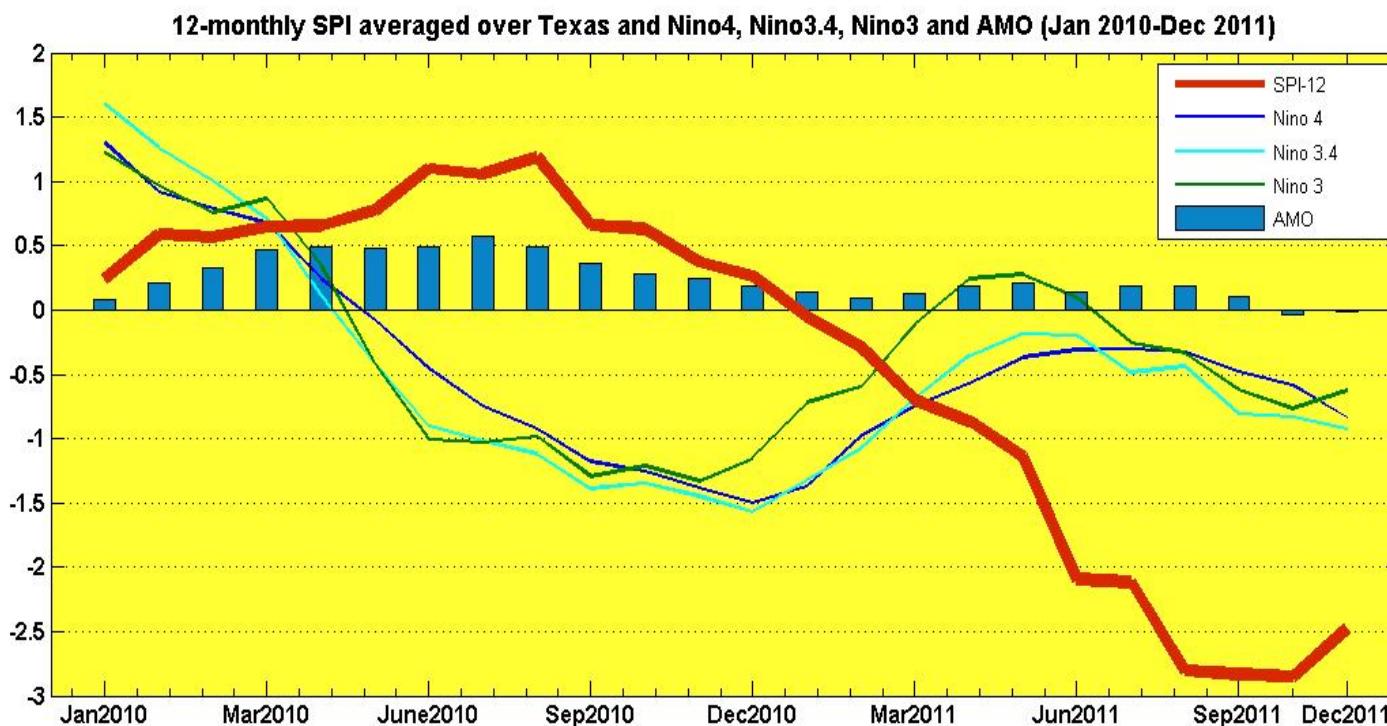
August 2011

National drought forecast analysis, <http://www.emc.ncep.noaa.gov/mmb/nldas/forecast/TSM/prob/>

Outline

1. What caused rapid drought intensification in late-spring/early summer?
2. How predictable are dry springs over Texas?
 1. Large-scale predictor patterns
 2. CFSv2 vs. NMME
5. Recap on processes driving drought over Texas important for CFSv2 improvements

AMO and La Nina do not appear to explain spring intensification



Knowns about Texas summer drought

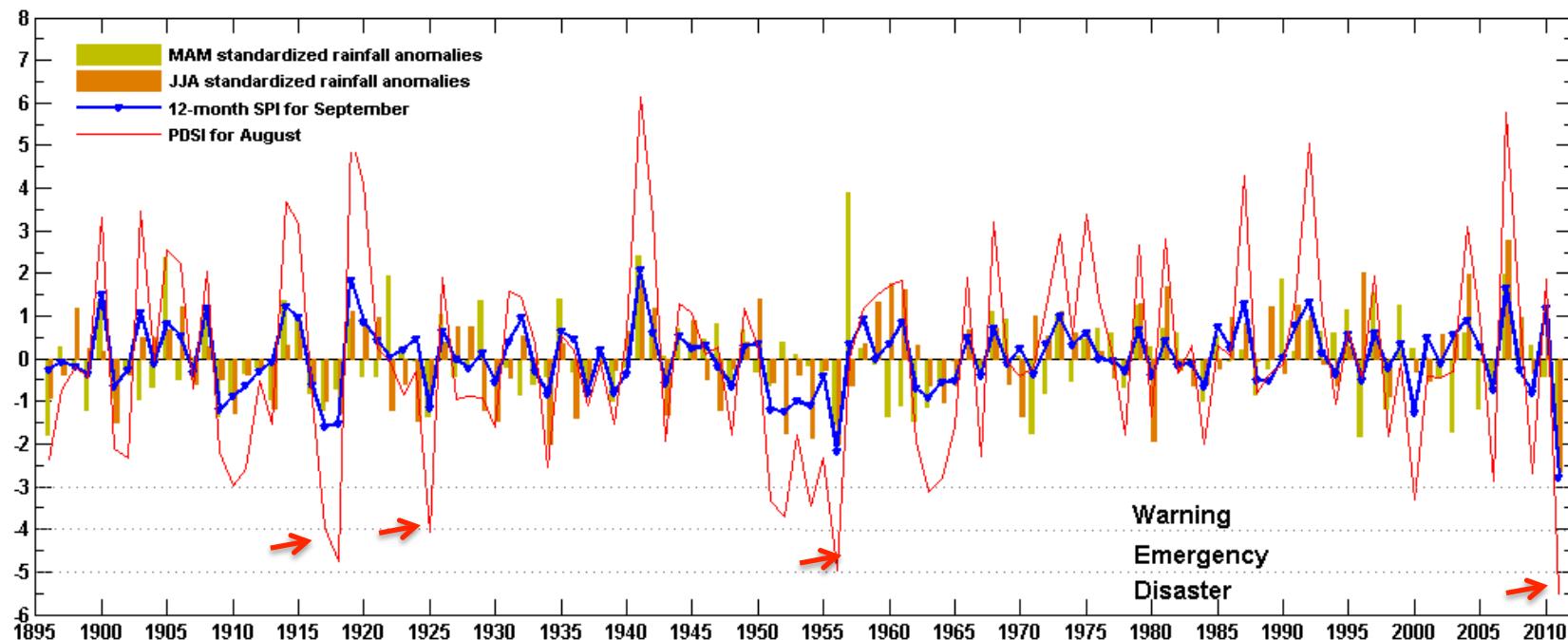
Myoung and Nielsen-Gammon (2010), *J. Climate*:

1. Summer rainfall deficit over Texas caused by increased Convective Inhibition (CIN) due to:
 - *Soil moisture feedback*
 - *Increased cap inversion due to westerly advection of warm air from Mexican Plateau*
2. Enhanced upper-level anticyclone that reduces synoptic disturbances

Question:

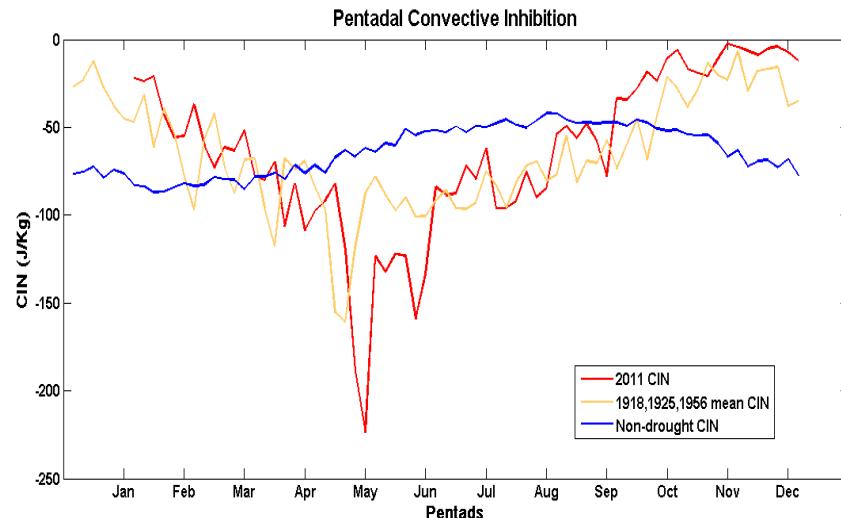
How importance is spring rainfall deficit to soil moisture feedback in severe-to-exceptional (PDSI < -3) summer drought?

Historical droughts and seasonal rainfall deficits

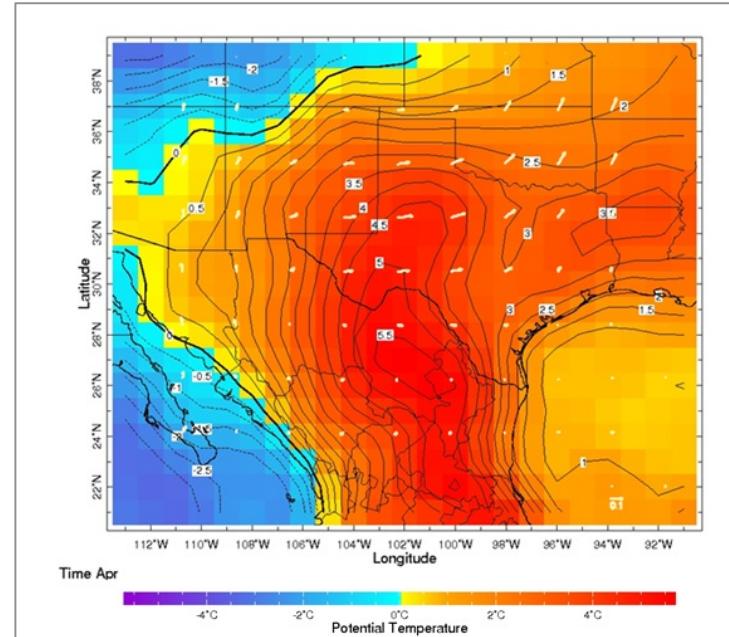
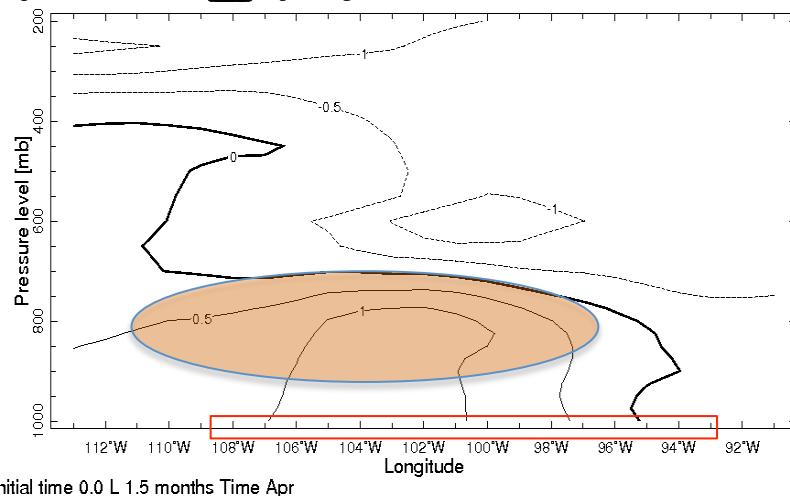


- Persistent rainfall deficits in DJF, MAM and JJA in 12 of 18 severe-to-extreme droughts, and 6 of 10 moderate droughts
- Preference for dry summers to follow dry springs
(chi-square test for $\text{DJF}_{\text{dry}} | \text{MAM}_{\text{dry}} | \text{JJA}_{\text{dry}}$ vs. $\text{DJF}_{\text{dry}} | \text{MAM}_{\text{wet}} | \text{JJA}_{\text{dry}}$ significant)

CIN and potential temperature (K) in April 2011



April 2011 K profile



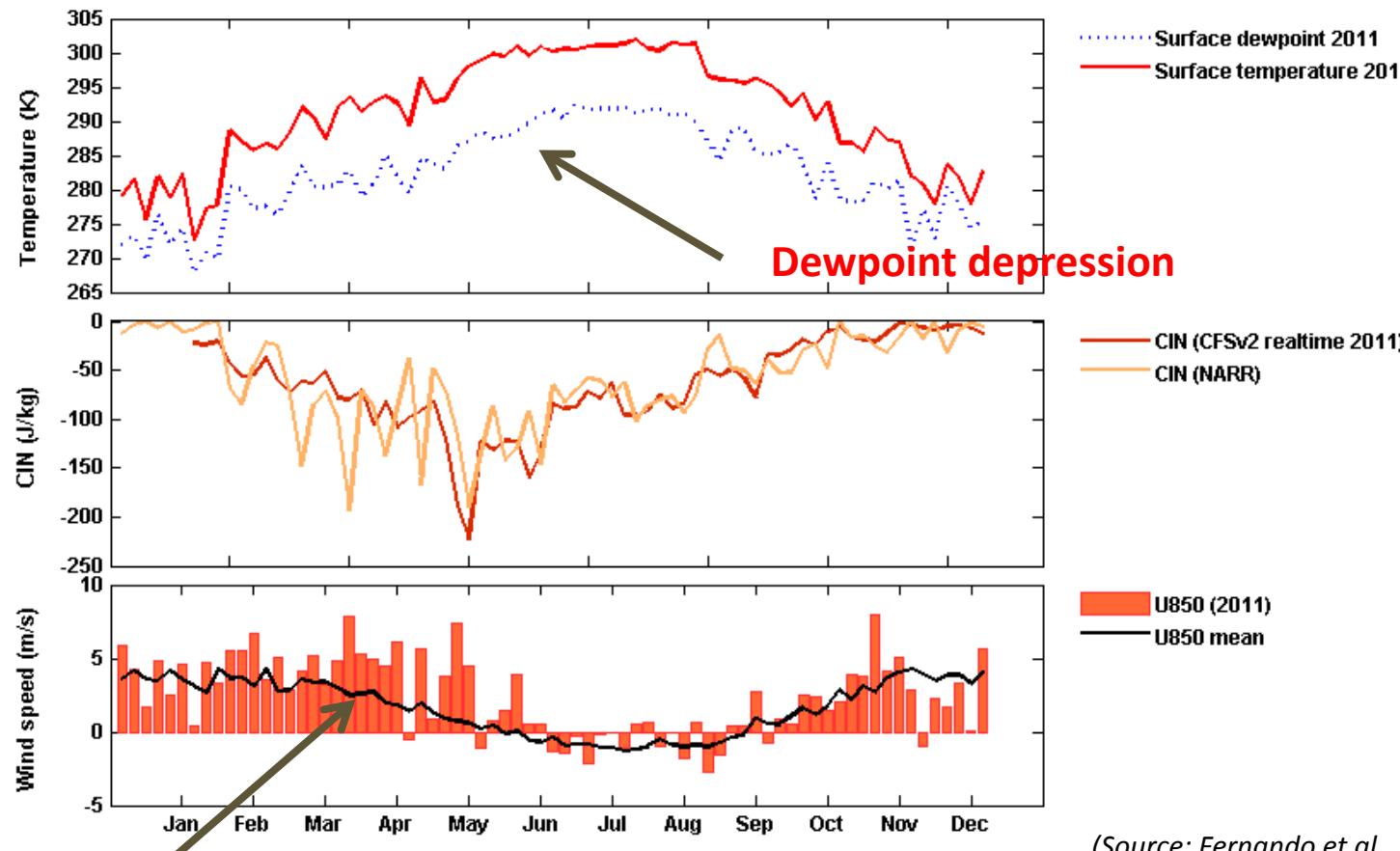
April 2011 K and wind anomalies

Data:

- PSD ESRL 20th Century Reanalysis v.2
- CFSv2 monthly realtime for 2011

(Source: Fernando et al., *in-prep.*)

U850, CIN, surface temperature and dewpoint

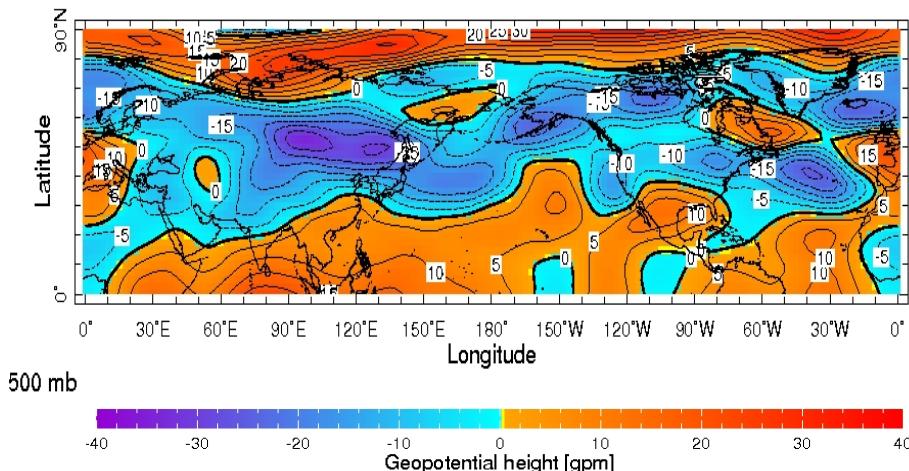


(Source: Fernando et al., *in-prep.*)

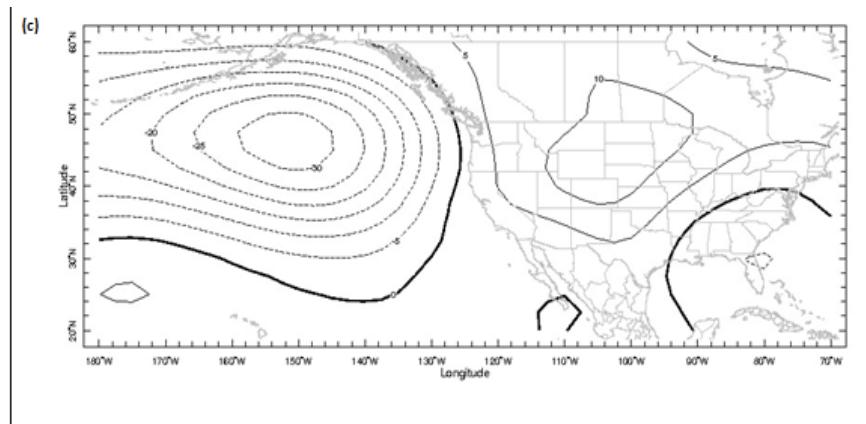
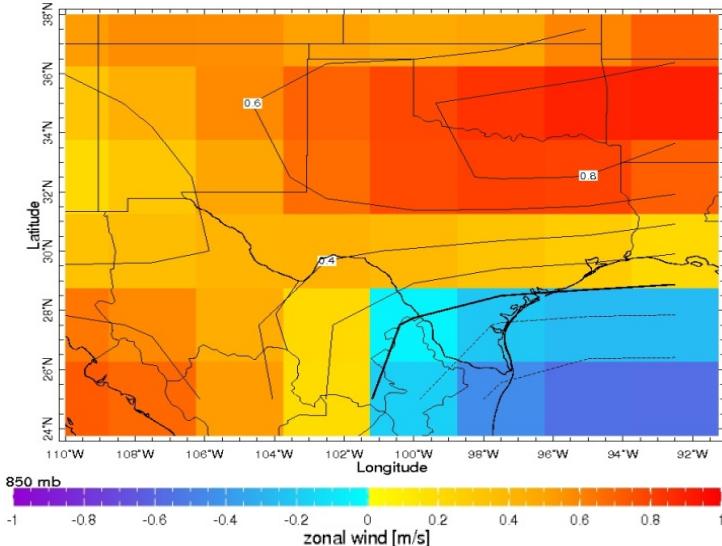
Anomalously strong westerlies

April U850 as a predictor of summer drought?

Composite z500 hPa anomaly



Composite U850 wind anomaly



(Source: Fernando et al., in-prep.)

Top right: April U850 composite in 12 severe-to-extreme drought years with DJF_{dry} | MAM_{dry} | JJA_{dry}

Top left: April 500 hPa geopotential height anomalies

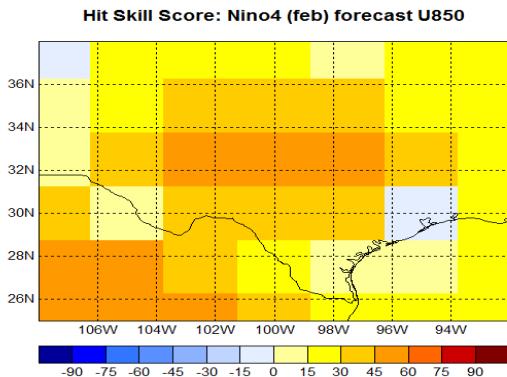
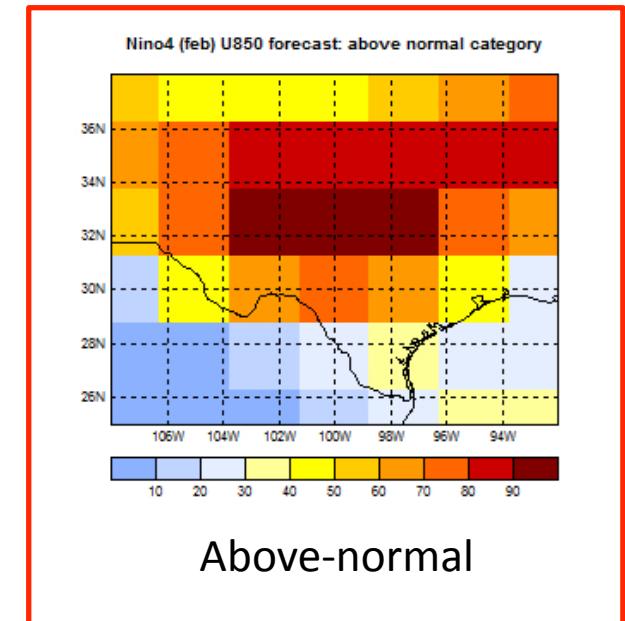
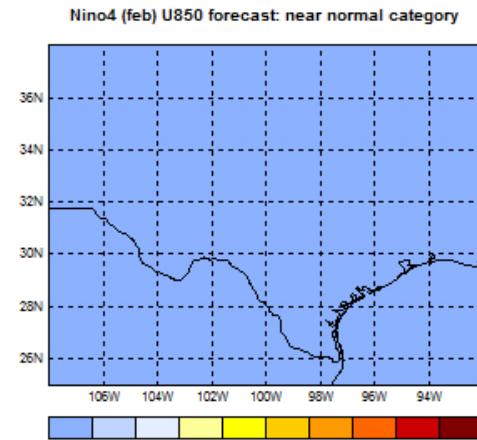
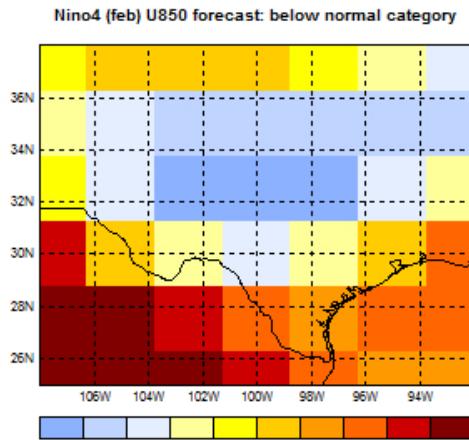
Bottom left: Canonical pattern of April 850 hPa geopotential that explains 92% of variance in April U850 over Texas

Predictability of April U850

1. Large-scale pattern of April z850 hPa anomalies correlated with April Pacific SSTs (Nino4, Nino3.4 and PDO action areas)

2. Assessment of predictability of April U850 based on predicted February SSTs from CFSv2 and NMME
 - Used CFSRR (1982-2010) and CFSv2 realtime (2011)
 - CFSv2 most-likely (4 models)
 - 6 models from NMME (GFDL, ECHAM_DC, ECHAM_AC, COLA, NASA, and CFSv2) archived at
<http://iridl.ldeo.columbia.edu/SOURCES/.Models/.NMME/>
 - Did not use CFSv1 as archived fields stop at Dec 2009

Could westerly wind anomalies in April 2011 have been predicted with observed SSTs?

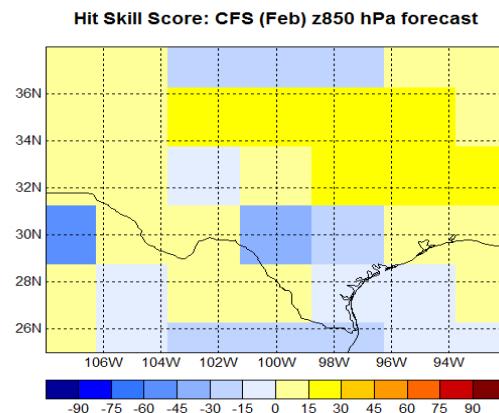
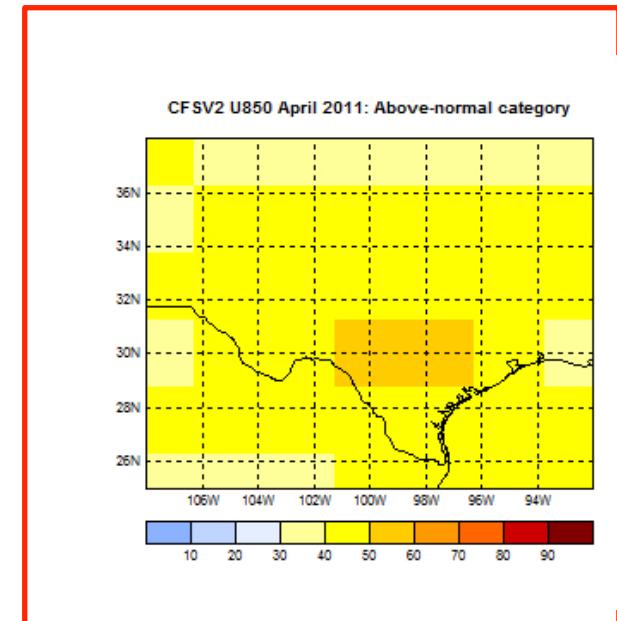
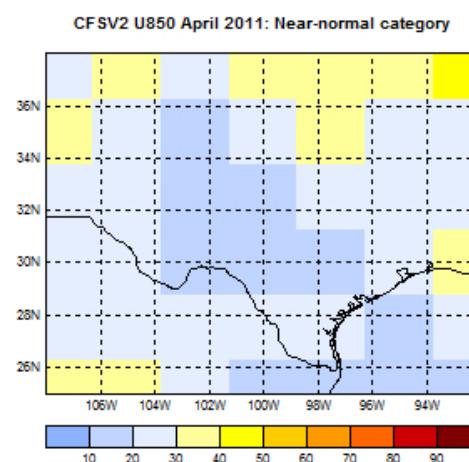
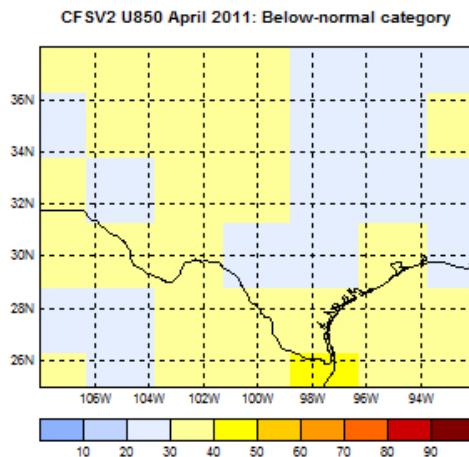


Wind forecast using observed Nino4 index for February

Overall skill: between 15-75% with central Texas Ranging from 45-75%. No skill in southeast corner. Similar to skill from Nino3.4(feb).

(Source: Fernando et al., in-prep.)

CFSv2 forecast most likely (Feb forecast Nino4)

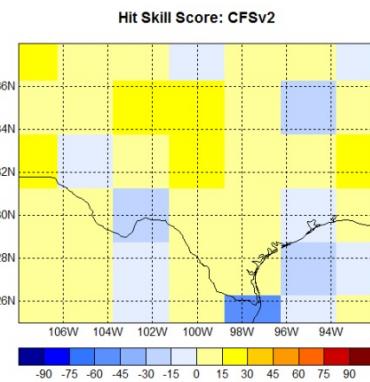
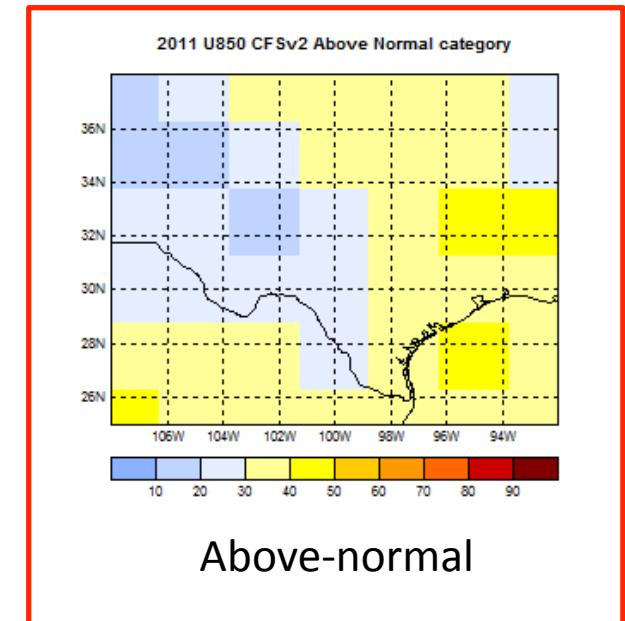
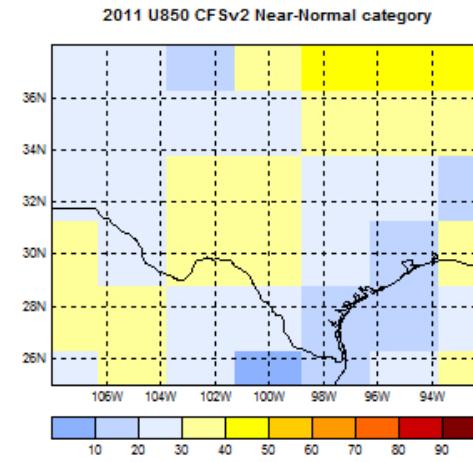
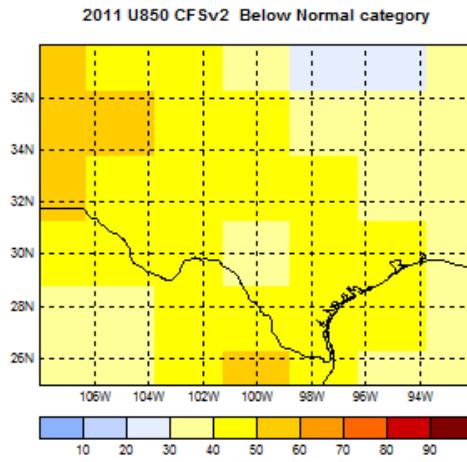


Wind forecast using forecast Nino4 index for February

Overall skill: between 15-30% in west central Texas corner. Similar to skill from Nino3.4(feb).

(Source: Fernando et al., in-prep.)

CFSv2 forecast (Feb forecast Nino4)

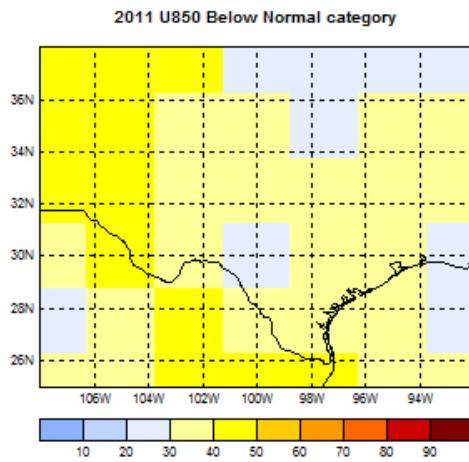


Wind forecast using forecast Nino4 index for February

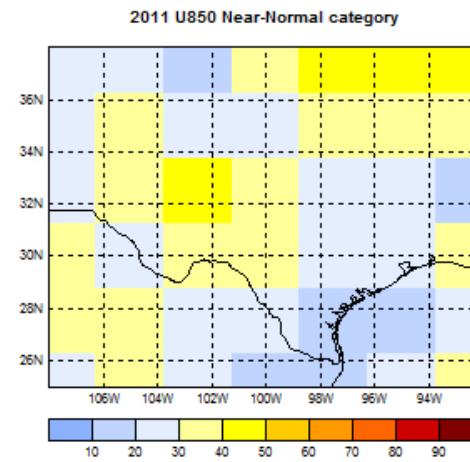
Overall skill: between 15-30% in west central Texas corner. Similar to skill from Nino3.4(feb).

(Source: Fernando et al., in-prep.)

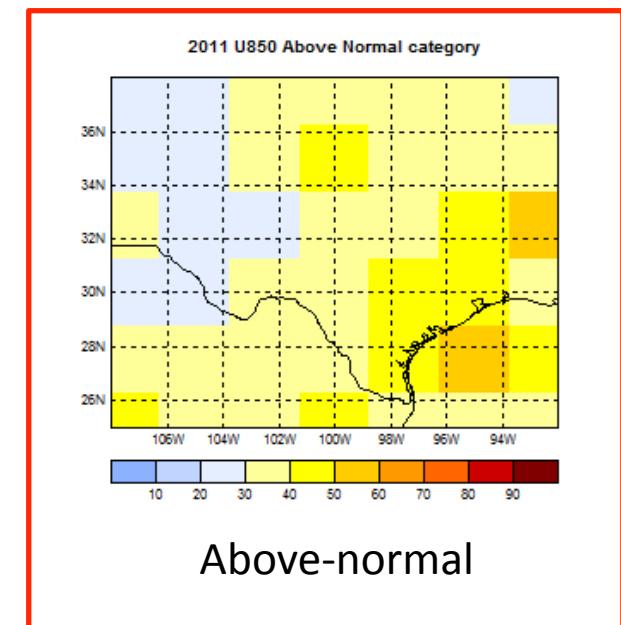
NMME forecast (Feb forecast Nino4)



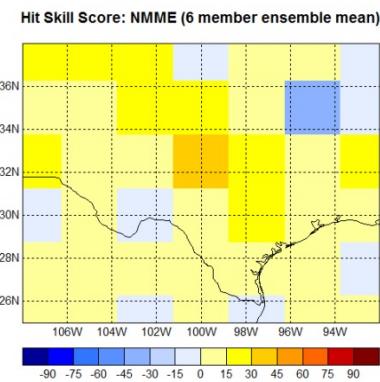
Below-normal



Near-normal



Above-normal

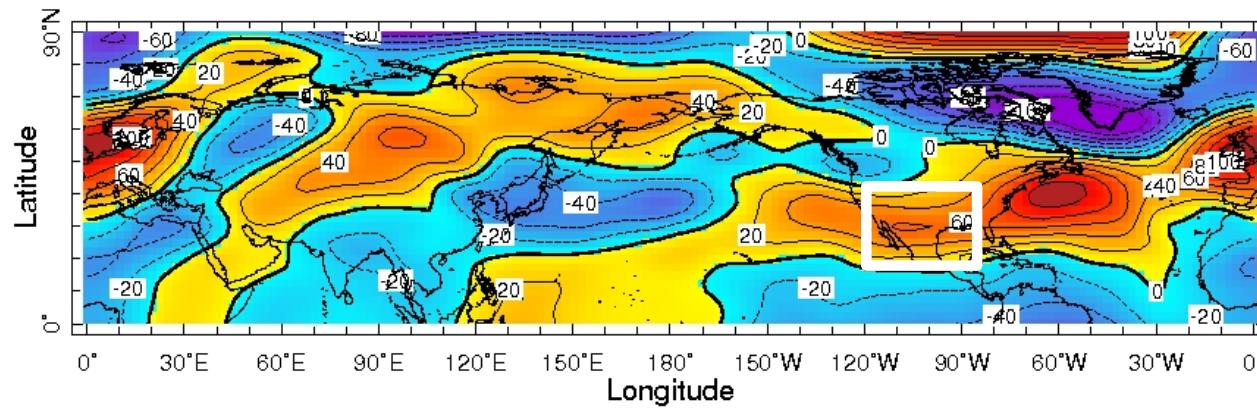


Wind forecast using forecast Nino4 index for February

Overall skill: between 40-60% in central Texas

(Source: Fernando et al., in-prep.)

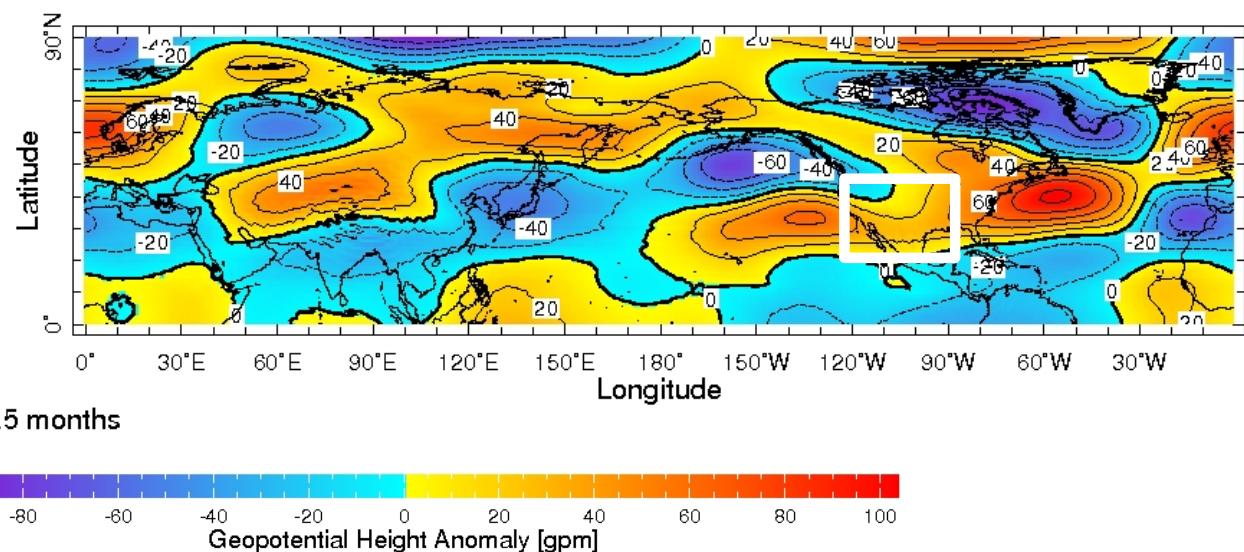
April 2011 500 hPa anomalies (obs vs. CFSv2)



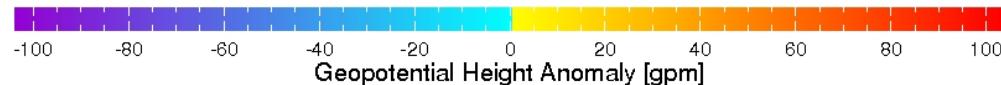
Observed (NCEP-CDAS1)

Pressure 500. mb Time Apr 2011

CFSv2 realtime (April)



0.5 months



Drought predictability recap and uncertainties

1. Spring season is critical in persistence of drought from winter through summer. Strong westerly winds in April inhibit rainfall in spring.
2. Soil moisture feedback may be important in increasing CIN from late-spring onwards
3. Establishment of anticyclone at 500 hPa (possible causes):
 - Large-scale circulation pattern linked to Pacific and Atlantic SSTs, NAO and WP pattern (PNA)? Pathway needs further analysis.
 - Compensational subsidence due to enhanced convection in the southeast?
 - Increased long-wave cooling > where lower tropospheric conditions (westerly advection) feed blocking?
4. CFSv2 most-likely forecast captures above-normal April U850 in 2011
5. CFSv2 multi-model ensemble does not perform as well as the NMME in forecasting U850
 - NMME performs better with Pacific SSTs
 - Helpful if fields such as geopotential height, u- and v-wind for the NMME is made available to the research community

Questions? 😊

Contact: nelun.fernando@jsg.utexas.edu

